project record

Experimental Blends of Dry Liquids

ED&T 2034 — APPLICATION OF DRY LIQUIDS

FEBRUARY 1975

U.S. Department of Agriculture
Forest Service
Equipment Development Center
Missoula, Montana

PROJECT RECORD

EXPERIMENTAL BLENDS OF DRY LIQUIDS

ED&T 2034

APPLICATION OF DRY LIQUIDS

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INTRODUCTION

In 1970 a project entitled Advanced Aerosol Methods for Aerial Spraying was assigned to the Missoula Equipment Development Center. Several methods were examined and the dry liquid concept was selected as the most promising method to pursue. Dry liquids are small particles of solids which have liquid adsorbed onto their surface and still retain flow properties of a dust.

Two field experiments have been conducted using dry liquids. The experiments have been reported in *Feasibility Study of a Dry-Liquid Insecticide Employed in a Coniferous Forested Environment* (1972) and *A Field Experiment on the Impaction of Zectran Particles on Spruce Budworm Larvae* (1973).

In preparation for the field experiments, many blends of various materials were produced. The purpose of this report is to document the results of all of the blending done.

RESULTS

In table 1 the properties of the solid materials used are summarized. Table 2 presents the physical properties of all blended materials in the order that the blending was done.

Figures 1 through 7 show the relationship between bulk density and percent liquid for each of seven solids combined with Dowanol TPM.

Table 1.-- *Dry liquids solid material properties*

Name of material	Type of material	Ph	Particle size & source size	Specific surface area M^2/gm	Shape of particle	Bulk density lb/ft^3	Bulk density gm/cc	Cost	Source	Color	Flow properties
Microcell-E	Synthetic hydrous calcium silicate. 54.3% SiO_2 25.1% CaO 3.6% Al_2O_3	8.4 (10% water slurry)	2.1μ - J-M brochure	110	Random w/many sharp edges	7.8(1) 5.4(2)	.125[1]	$0.11/lb to $0.08/lb 1968	Johns-Manville 22 E. 40th St. New York, NY 10016	Off-white	Slight tendency to stick together from electrostatic charges
Cab-O-Sil	Fumed silica $SiCl_4+2H_2O \xrightarrow{1100C} SiO_2+4HCl$	3.5 to 4.2	0.012μ - Cabot brochure	200 ± 25	Chain like	2.9[1] 2.3[2]	.0465[1]	$0.77 to $2.00/lb Apr 1971	Cabot Corporation 125 High St. Boston, MA 02110	White	Like Microcell-E only more so
Attaclay	Attapulgus Clay	8.0	18μ*, .6 x .01μ ultimate particle size	125	Needle shape	25.5[1]	.4085[1]	$0.45/lb	Engelhard Min. & Met. Corp. Edison, NJ 08817	Cream	Pours like sand
Santocel-Z	97.5% SiO_2 2.5% sodium sulfate	4.0 (4% slurry @ 25C)	2.0μ avg. Agglomerate, .01 to .02 ultimate particle from Monsanto brochure	280	Globs of rounded particles	2.4[1] 3.75[2]	.0384[1]		Monsanto Company Inorganic Chem. Div. St. Louis, MO 63166	White	Like Cab-O-Sil
Hysil 233	Amorphous synthetic silica 97.5% SiO_2 anhydrous basis	6.5-7.3	1 to 100μ * .021μ ultimate particle size	150	Rounded particles white agglomerate like bunches of grapes	10.4[1] 10-12[2]	.1673[1]	$0.08 to $0.10 in over ½-T lots, 1972	PPG Industries One Gateway Center Pittsburgh, PA 15222	White	Like dry flour
Celite 209	Diatomaceous silica 86.7% SiO_2 3.3% Al_2O_3	7.0	5-50μ ultimate J-M brochure	10-20	Random Diatom shapes; round, eliptical, stick, etc.	8.0[2]		$0.20/lb to $0.06/lb	Johns-Manville	Buff	Between sand and dry flour
Celite 400	Diatomaceous silica 85.7% SiO_2 3.8% Al_2O_3	7.0	5-50μ ultimate J-M brochure	10-20	Same as Celite 209	7.0[2]		$0.20/lb to $0.06/lb	Johns-Manville	Buff	Like Celite 209

(1)MEDC

(2)Manufacturer

*Average agglomerate

Table 2.--*Properties of dry liquid blends*

Batch No.	Blend				Bulk density		Particle size Micron	Mixture Vol./ Orig. solid vol.	Degree of fluorescence	Wet or dry	Remarks
	Solid	% by wt.	Liquid	% by wt.	lb/ft3	gm/cc					
Pure Microcell-E	Microcell-E	100	None	0	5.4-8.0 depends on who determined B.D.	.125	7-15 μ 40-200 μ clumps Average agglomerate size from mfr = 5 μ	1.0		Dry	Translucent in appearance. Behaves like heavy smoke when blown from duster. Would not travel against wind.
1	Microcell-E	50	Dowanol	50	15.2	.2435	7-15 μ 40-200 μ clumps Average agglomerate size from mfr = 5 μ	1.0		Dry	Translucent in appearance. Behaves like heavy smoke when blown from duster. Would not travel against wind.
2	Microcell-E	85	Dowanol	15	8.6	.138	7-15 μ 40-200 μ clumps Average agglomerate size from mfr = 5 μ	1.1		Dry	Translucent in appearance. Behaves like heavy smoke when blown from duster. Would not travel against wind.
3	Microcell-E	66.7	Dowanol	33.3	12.6	.202	7-15 μ 40-200 μ clumps Average agglomerate size from mfr = 5 μ	0.9		Dry	Translucent in appearance. Behaves like heavy smoke when blown from duster. Would not travel against wind.
4	Microcell-E	40	Dowanol	60	15.6	.250	7-15 μ 40-200 μ clumps Average agglomerate size from mfr = 5 μ	1.3		Dry	More opaque than mixtures 1 through 3. Behaves like heavy smoke when blown from duster. Would not travel against wind.
5	Microcell-E	30	Dowanol	70	15.9	.255	7-15 μ 40-200 μ clumps Average agglomerate size from mfr = 5 μ	1.6		Very wet	More opaque than mixtures 1 through 3. Had definite trajectory when blown from duster. Went greater distance than batches 1 through 4 before wind carried them. Part of mixture dropped to bottom of stream and behaved more like liquid than smoke. Upper portions of stream behaved like thin smoke.
Pure Cab-O-Sil	Cab-O-Sil	100	None	0	2.9	.0465	5-10 μ Average agglomerate size from mfr = 3μ. Ultimate particle size from mfr = .01 -.02 μ	1.0		Dry	Two to thousands of particles in clumps. Smallest particles appear to be made up of smaller partioles. Large chunks fall out of stream of Cab-O-Sil.
6	Cab-O-Sil	50	Dowanol	50	6.8	.109	5-10 μ Average agglomerate size from mfr = 3μ. Ultimate particle size from mfr = .01 -.02 μ	0.9		Dry	Two to thousands of particles in clumps. Smallest particles appear to be made up of smaller particles. No chunks fall out of stream.
7	Cab-O-Sil	66.7	Dowanol	33.3	4.22	.0676	5-10 μ Average agglomerate size from mfr = 3μ. Ultimate particle size from mfr = .01 -.02 μ	1.0		Dry	Two to thousands of particles in clumps. Smallest particles appear to be made up of smaller particles. No chunks fall out of stream.
8	Cab-O-Sil	85	Dowanol	15	2.96	.0474	5-10 μ Average agglomerate size from mfr = 3μ. Ultimate particle size from mfr = .01 -.02 μ	1.1		Dry	Two to thousands of particles in clumps. Smallest particles appear to be made up of smaller particles. No chunks fall out of stream.

Table 2.--*Properties of dry liquid blends (con.)*

Batch No.	Blend: Solid	Blend: % by wt.	Blend: Liquid	Blend: % by wt.	Bulk density: lb/ft³	Bulk density: gm/cc	Particle size Micron	Mixture Vol./ Orig. solid vol.	Degree of fluorescence	Wet or dry	Remarks
9	Cab-O-Sil	40	Dowanol	60	11.5	.184	5-10 μ Average agglomerate size from mfr = 3μ. Ultimate particle size from mfr = .01 -.02 μ	0.6		Dry	Two to thousands of particles in clumps. Smallest particles appear to be made up of smaller particles. No chunks fall out of stream.
10	Cab-O-Sil	30	Oowanol	70	22.3	.357	5-10 μ Average agglomerate size from mfr = 3μ. Ultimate particle size from mfr = .01 -.02 μ	0.4		Dry	No. 10 is more opaque than other Cab-O-Sil mixtures. No chunks fall out of stream.
Attaclay	Attaclay	100	None	0	25.5	.4085	18 μ from mfr. Ultimate particle size	1.0		Slightly Wet	Macroscopically--somewhat wet. Microscopically--appears to be very fine
11	Attaclay	85	Oowanol	15	27.6	.442		1.1		Ory	Macroscopically--lighter and "drier" than pure Attaclay. Little tendency to form clumps. Translucent.
12	Attaclay	66.7	Oowanol	33.3	31.0	.497		1.2		Quite Wet	Macroscopically--quite wet. Tends to stick wherever it is placed. Microscopically--identical to batch 11.
Santocel-Z	Santocel-Z	100	None	0	2.43		2 μ from mfr. Ultimate particle size = .01-.02 μ from mfr				Individual particles "very tiny." Sometimes "jump" (electrostatic charge?). Translucent. Lots of big particles fall out of 100% Santocel.
13	Santocel-Z	85	Oowanol	15	1.43	.0229		2.0		Ory	Individual particles "very tiny." Sometimes "jump" (electrostatic charge?). Translucent; but no large particles falling out.
14	Santocel-Z	66.7	Oowanol	33.3	1.77	.0284		3.0		Ory	Individual particles "very tiny." Sometimes "jump" (electrostatic charge?). Translucent; but no large particles falling out.
15	Santocel-Z	50	Oowanol	50	3.25	.521		1.4		Dry	Individual particles "very tiny." Sometimes "jump" (electrostatic charge?). Translucent; but no large particles falling out.
16	Santocel-Z	40	Oowanol	60	8.9	.143		0.7		Ory	Particles are opaque rather than translucent. No "jumping."
17	Santocel-Z	30	Oowanol	70	16.0	.256		0.5		Slightly Wet	Somewhat wet macroscopically. Identical to batch 16 microscopically.
18	Santocel-Z	40	Oowanol	60	SEE BATCH 16					GENERAL NOTE:	Santocel "Z" appears to expand with the addition of Oowanol, except for batches 16, 17, & 18 which did shrink considerably.
Pyrophilite											
20	Pyrophilite	85	Oowanol	15							
21	Pyrophilite	95	Dowanol	5							

Table 2.--*Properties of dry liquid blends (con.)*

Batch No.	Blend: Solid	% by wt.	Liquid	% by wt.	Bulk density: lb/ft³	gm/cc	Particle size Micron	Mixture Vol./ Orig. solid vol.	Degree of fluorescence	Wet or dry	Remarks
22	Pyrophilite	90	Dowanol	10							
23	Phrophilite	90	Dowanol Zectran	7.5 2.5							
24	Pyrophilite	90	Dowanol Zectran	5 5							Dowanol and Zectran heated to form solution. When cooled, Zectran precipitated out.
25	Attaclay Pyranine	80	Water Dowanol Pyranine	5.8 14.2 .019					Slight		See 26.
26	Attaclay	80	Water Glycerine Dowanol Pyranine	3.33 3.33 13.33 .019					None, but can be made fluorescent by holding over boiling water. More fluoresoent than 25.	Drier than 25	1. Water + glycerine + PTS → ugly brown. Highly fluorescent liquid. 2. Water + glycerine + Dowanol + PTS → ugly brown mildly fluorescent liquid. Viscous liquid. Slow to mix.
27	Attaclay	80	Water Glycerine Dowanol Pyranine	3.33 3.33 13.33 .04					More than 25 or 26.		Liquid fluoresces in daylight.
28	Attaclay	80 0.04	Water Glycerine Pyranine	10 10 .04					Fluorescent w/o steam		No Dowanol.
GENERAL INFORMATION ON PREPARATION OF MIXTURES 25, 26, 27, 28			10 grains Pyranine + 1 lb. 10 oz. Dowanol is fluorescent. After awhile, a sediment forms at bottom of container. The liquid remaining + 6 lb. Attaclay is NOT fluorescent except when water is added to the dry liquid. Humidifying the liquid has no effect. No fluorescent particle visible under microscope with batch. 8/18/69								
29	Attaclay	60	Water Glycerine Pyranine	20 20 0.2			20		Highly fluorescent	Drier than similar blend w/ Dowanol	Fluorescent particles not visible with microscope.
30	Cab-O-Sil Pyranine	30 0.2	Water Glycerine Pyranine	35 35 0.2			20			Most fluorescent yet.	Visible under microscope without steaming.
31	Cab-O-Sil Pyranine	30 0.2	Water Glycerine	35 35			20			Most fluorescent yet.	Visible under microscope without steaming. 8/20/69

GENERAL NOTE ON SAMPLES 29, 30, 31

Samples which fluoresced brightly on 9/19/69 lost fluorescence by 9/22/69. Loss of water probable cause of reduced fluorescence. New samples (wet) of 29, 30 and 31 are highly fluorescent with 30 the brightest.

9/30/69 Batch No. 30 dusted on fir tree. Fluorescent particles can be spotted.

10/1/69 Above no longer fluorescent. Prolonged steaming causes a partial return of fluorescence.

10/2/69 Dipped specimen of fir tree under microscope:
2:05 p.m. Brightly fluorescent particles visible
2:35 p.m. Many particles no longer visible. Those visible are less fluorescent than at 2:05 p.m.
3:0 p.m. Most fluorescent particles are invisible.
3:35 p.m. Add drop of water to fir needle. Most particles regain fluorescence.
4: p.m. Fluorescence is weak
4:15 p.m. Partioles nearly invisible

10/3/69 Particle highly fluorescent on 10/3 are fluorescent on 10/4 if the stem is kept in water and a bag is placed over foliage and sealed to the container.

10/6/69 Above samples have particle with low level fluorescence.

Table 2.--*Properties of dry liquid blends (con.)*

Batch No.	Blend: Solid	% by wt.	Liquid	% by wt.	Bulk density lb/ft³	Bulk density gm/cc	Particle size Micron	Mixture Vol./ Orig. solid vol.	Degree of fluorescence	Wet or dry	Remarks
32	Cab-O-Sil Pyranine	30 0.2	Water Glycerine Dowanol	22.5 22.5 25					Less than batch 31		Dowanol added before water, Glycerine, Pyranine mix.
33	Cab-O-Sil Pyranine	27.3 0.18	Water Glycerine Dowanol	29.5 20.4 22.7					W/o Dowanol same as 30. Fluorescence reduced when Dowanol added.		Water, Glycerine, Pyranine added before Dowanol, formed "glomules."
34	Cab-O-Sil Pyranine	25 0.17	Water Glycerine Dowanol	35.4 18.8 20.7							Large "glomules."
35	Cab-O-Sil Pyranine	27.3 0.18	Water Glycerine Dowanol	34.1 15.9 22.7					Some fluorescence before "glomules" formed.		Small glomules.
36	Cab-O-Sil Pyranine	30 .2	Water Glycerine	35 35							
37	Cab-O-Sil Pyranine	30° .2	Water Glycerine	35 35							
38	Cab-O-Sil Gelatin Pyranine	29.6 1.2 0.2	Water	69					10/23 Very bright-fresh 10/15/69. Very faint-dried 2½ hr. Restored by humidifying 10/27 & 11/5/69 Undried sample Very bright (Geled)		10/15/69 - Dusted some fir trees. No F.P.'s visible until needles were steamed. More F.P.'s on tree dusted from 20 yd than from 50 yd.
39	Cab-O-Sil Gelatin Pyranine	29.9 1.1 0.14	Water Dowanol	44.9 23.9					Less than 38. Bluish rather than yellow.		Glomules formed when Dowanol added.
40	Cab-O-Sil	30	Water Glycerine Pyranine	35 35 .2							
41	Cab-O-Sil	29.8	Water Gelatin Pyranine	68.7 1.5 .2							
42	Cab-O-Sil	32.8	Water Gelatin Pyranine	65.6 1.4 .2							
43	Cab-O-Sil	30.2	Glycerine Water Pyranine	34.8 34.3 .2							
44	Cab-O-Sil	30.2	Glycerine Water Pyranine	34.8 34.5 .2							
45	Microcell-E	50	Pyrethrum X-2385-70	50							
46	Microcell-E	40	Pyrethrum X-2385-70	60							

Table 2.--*Properties of dry liquid blends (con.)*

Batch No.	Blend: Solid	% by wt.	Blend: Liquid	% by wt.	Bulk density lb/ft³	Bulk density gm/cc	Particle size Micron	Mixture Vol./ Orig. solid vol.	Degree of fluorescence	Wet or dry	Remarks
47-54	Microcell-E	50	Pyrethrum X-2385-70	50							Total 36 lb. - shipped to MGK.
55-74	Cab-O-Sil	50	Dowanol	50							
75-83	Cab-O-Sil	30.5	Dowanol	69.5							Two sub blends of 2 lb. Cab-O-Sil + 1-1/8 lb. TPM were made; then these were mixed with 2 lb. 5 oz. TPM. 9/3/70
84	Cab-O-Sil	33	Water	67							
85	Cab-O-Sil	33	Water	67							
86	Cab-O-Sil	33	Water	67							
87	Cab-O-Sil	33	Water	67							
88	Cab-O-Sil	33	Water	67							
89	Cab-O-Sil	33	Water	67							
90	Microcell-E	50	MGK F-7060	50							
91	Microcell-E	50	MGK F-7061	50							
92	Microcell-E	50	MGK F-7062	50							
Special Liquid "A"			SFG Dowanol	1 99					Very high at start. 1 hr - fainter than "B"; 3-1/2 hr - fainter than "B"; back in sun; 3-3/4 hr - brighter than "B"; 4-3/4 hr same as "B".		Paper wet with mixture, then placed in sunshine before checking fluorescence.
Special Liquid "B"			SFG Wingstay Dowanol	1 1 98					3-1/2 hr - very high; 3-3/4 hr less bright than "A"; 4 hr - brighter than "A"; 4-3/4 hr - same as "A".		Paper wet with mixture, then placed in sunshine before checking fluorescence. Wingstay, Inc. viscosity of TPM.
93 4/27/71	Microcell-E	50	Dowanol SFG Zectran	40 1 9					Fluorescent foliage placed in sunlight. 1/4 hr - fluorescent; 1/2 hr - somewhat weaker; 2 hr - same.		
									New test. Bright at start 1/4 hr - little fainter; 1/2 hr - same; 3/4 hr - half as bright as 1/2 hr; 1-3/4 hr - fainter; 20 min on slide changed from high to low, but stable fluorescence 35 min.		Particles not exposed to U.V. retained fluorescence better. All lost very bright fluorescence in 15 to 20 minutes.

Table 2.--*Properties of dry liquid blends (con.)*

Batch No.	Blend: Solid	% by wt.	Liquid	% by wt.	Bulk density: lb/ft^3	gm/cc	Particle size Micron	Mixture Vol./ Orig. solid vol.	Degree of fluorescence	Wet or dry	Remarks
94-180	Microcell-E	39.6	Oowanol Zectran Tinopal	48.4 11 1	12 lb/ft^3	.0320	No. med. size = 2 μ Mass med. size = 13 μ MMD = 5.8 μ				432 lb. blended for field tests. Sized by Metronics, Oct. 1971.
181-226	Microcell-E	40	Oowanol	60							225 lb. for calibration of test equipment. See Batch #4. Finished 6/14/71
300	Celite 400	50	Dowanol	50	10.4	.166			None		Very glunky; about like 70-30 Microcell. Celite 400 has published MMD of 35.5μ.
301	Celite 400	60	Oowanol	40	8.97	.144			None		Still somewhat glunky.
302	Celite 400	70	Dowanol	30	7.75	.125			None		Dry, but sticks in blender.
303	Celite 209	50	Dowanol	50	14.8	.237			None		Somewhat moist; different from C-400. Celite 209 has published MMD of 11.2μ.
304	Celite 209	60	Oowanol	40	10.6	.170			None		Quite dry, but can be molded.
Hysil-233	Hysil-233	100			10.44	.1673					
305	Hysil-233	50	Oowanol	50	19.66	.3150	No. med. size = 17.3 μ Mass med. size = 43.8 μ MMD = 25.9 μ				Fluffy, free-flowing. Sizing by Metronics.
306	Hysil-233	50	Dowanol	50							
307	Hysil-233	70	Dowanol	30	13.27	.2125					
308	Hysil-233	40	Dowanol	60	21.11	.3382					Not free-flowing; diffioulties in blending, so blend is not typical.
309-330	Hysil-233	50	Oowanol	50							See Batch 305. 1/5/72
331-350	Microcell-E	40	Dowanol	60							See Batch #4.
353-362	Microcell-E	50	Dowanol	50							See Batch #1.

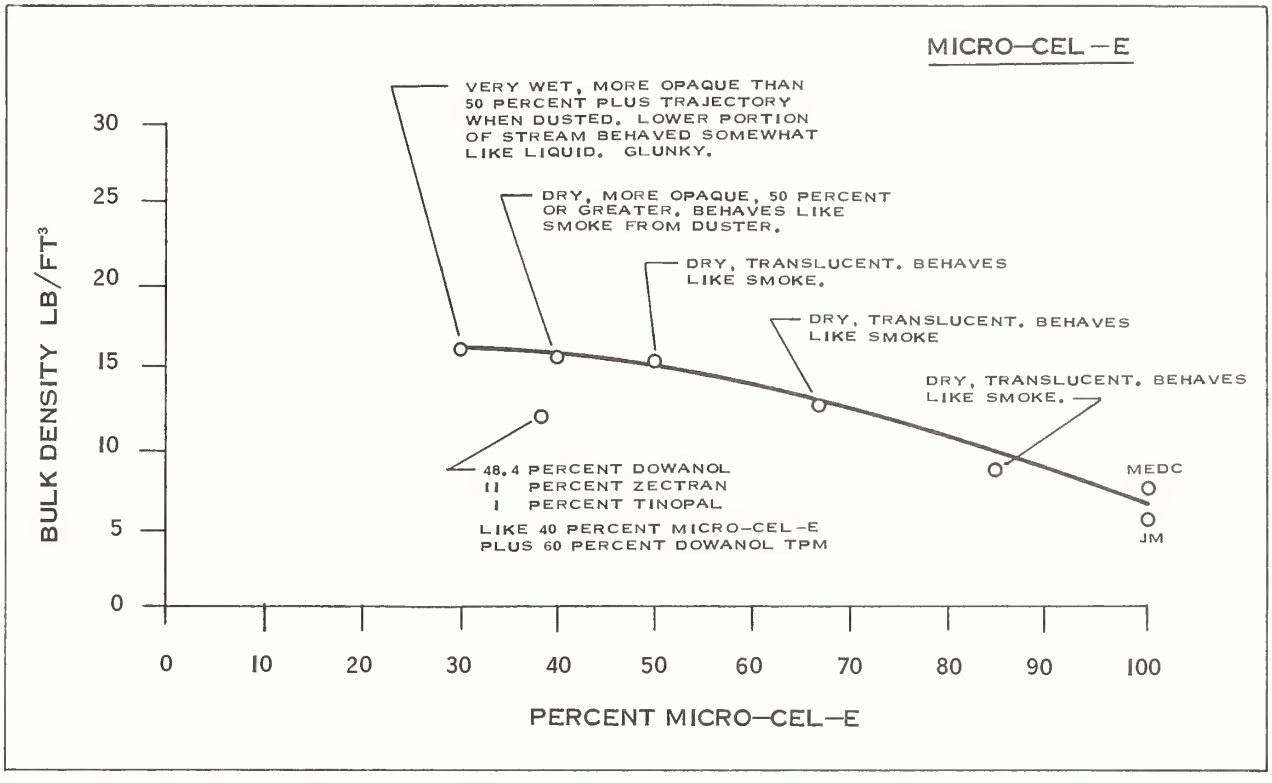

Figure 1.--Effect of liquid concentration on bulk density of Micro-cel-E.

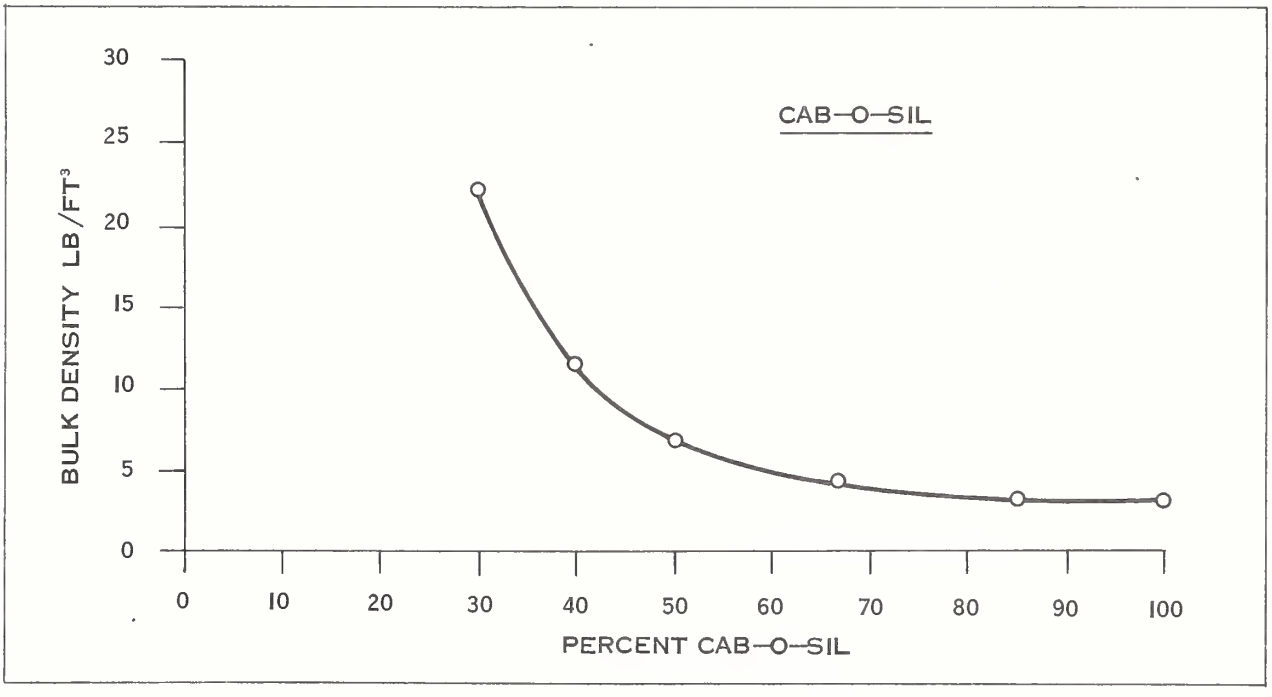

Figure 2.--Effect of liquid concentration on bulk density of Cab-o-sil.

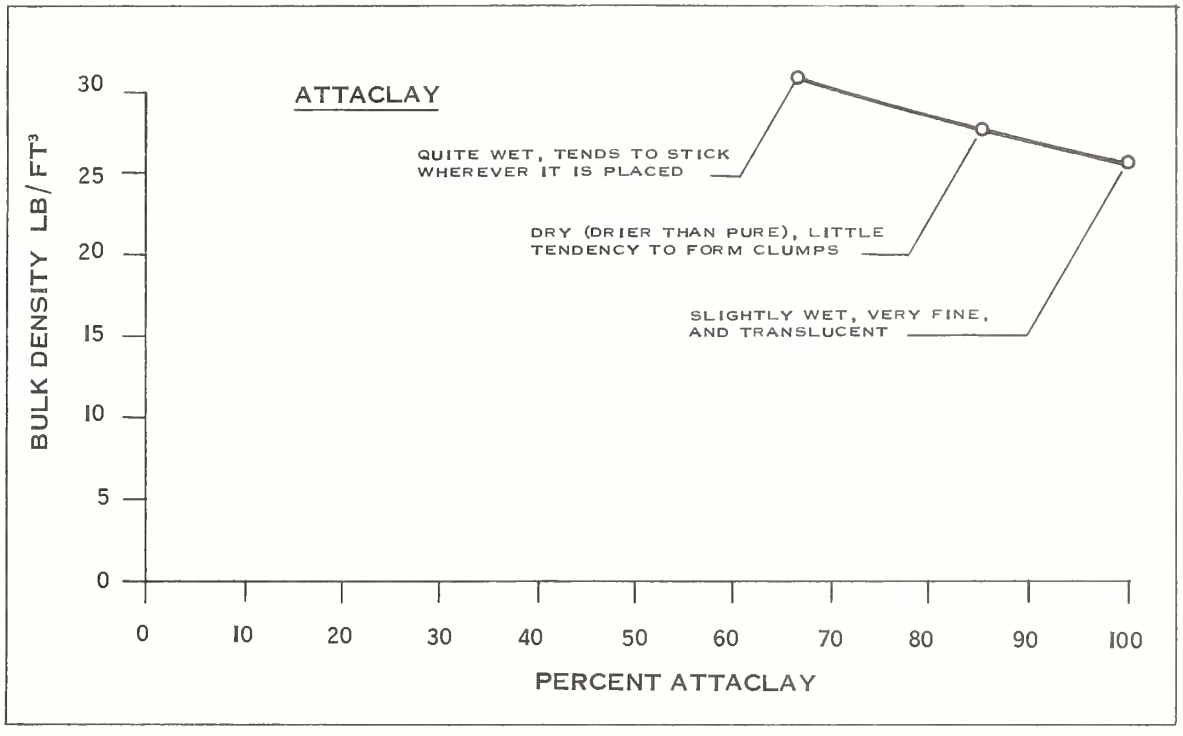

Figure 3.--Effect of liquid concentration on bulk density of Attaclay.

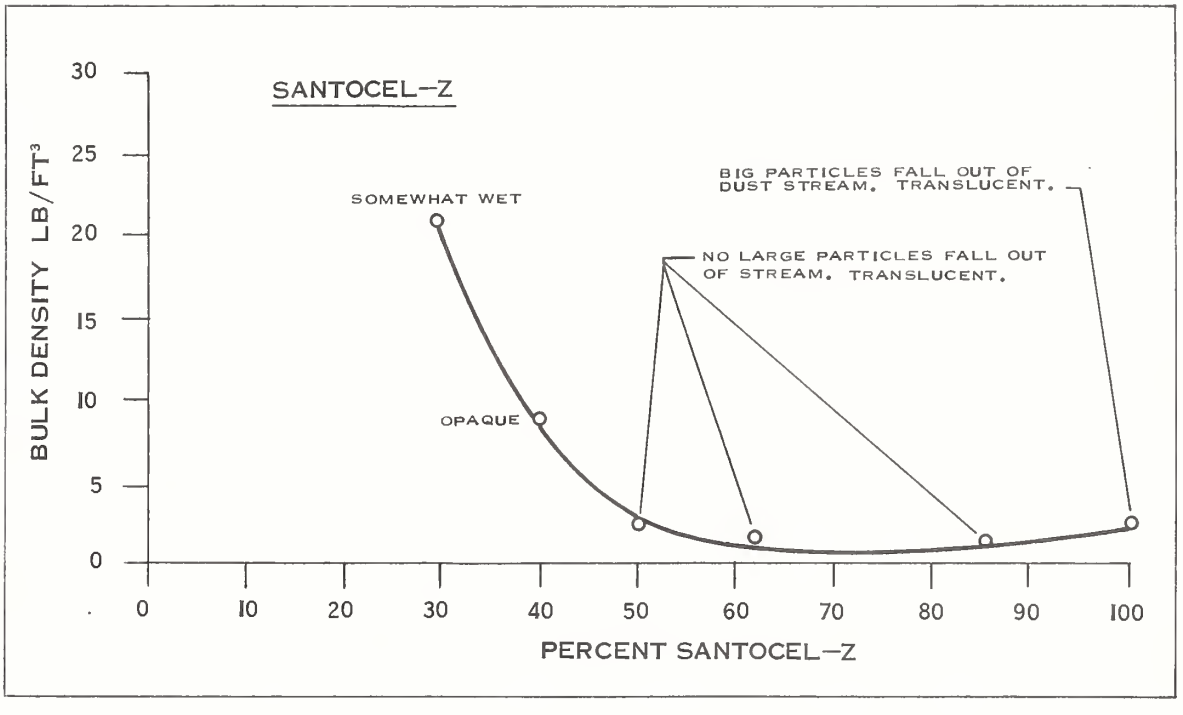

Figure 4.--Effect of liquid concentration on bulk density of Santocel-Z.

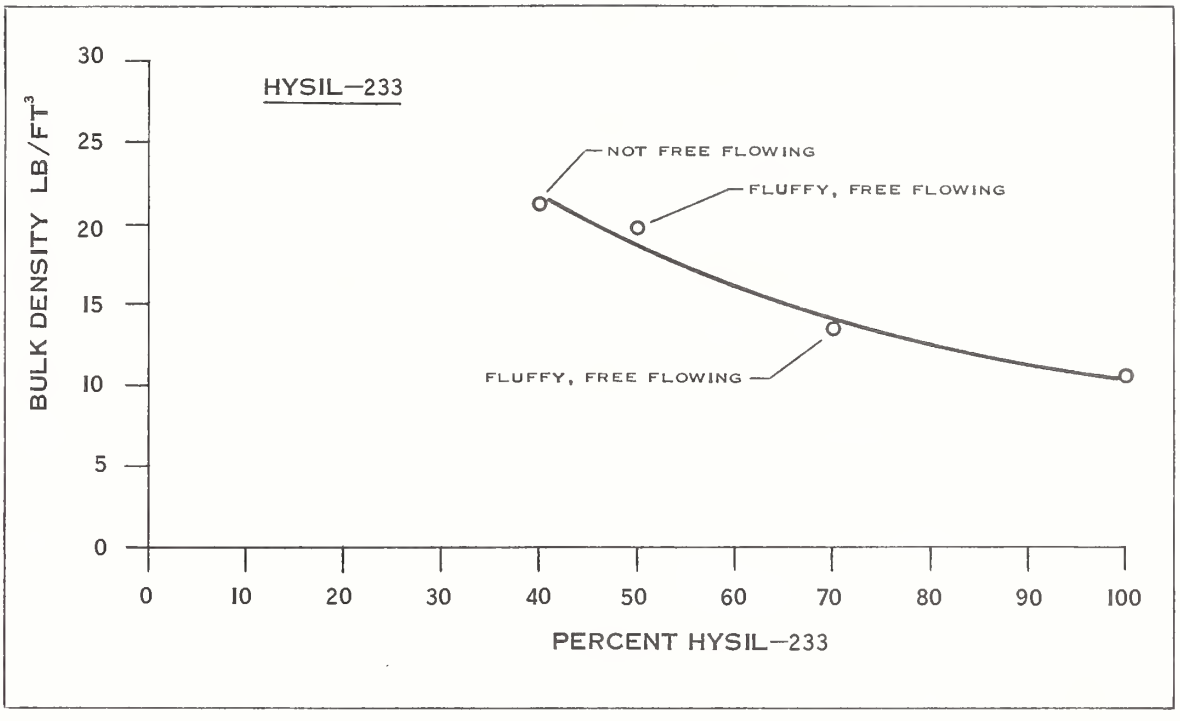

Figure 5.--Effect of liquid concentration on bulk density of Hysil-233.

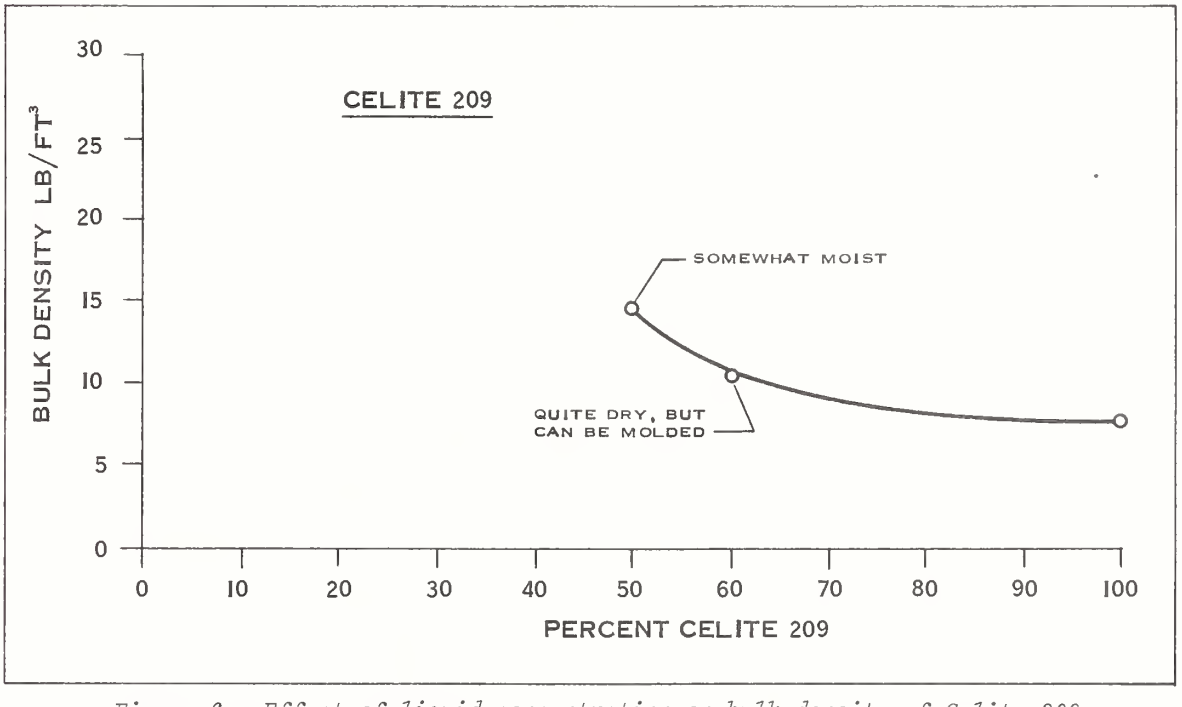

Figure 6.--Effect of liquid concentration on bulk density of Celite 209.

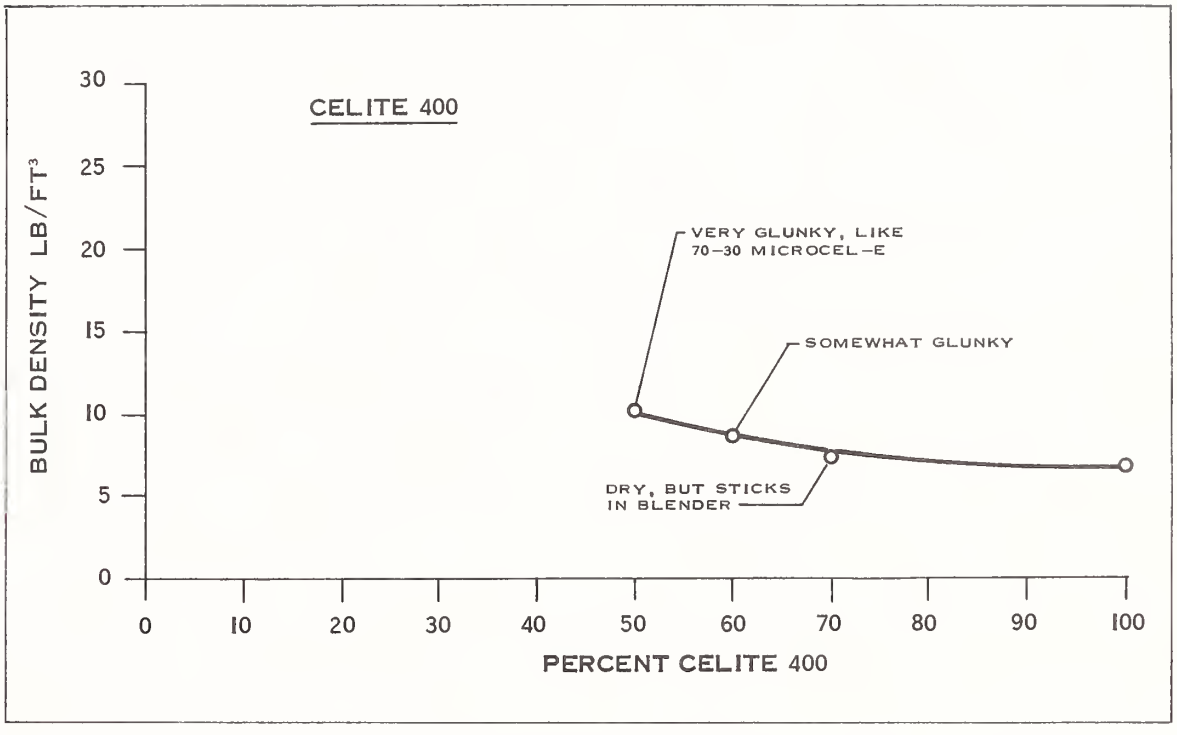

Figure 7.--Effect of liquid concentration on bulk density of Celite 400.